DOCUMENT RESUME

ED 394 836 SE 058 330

AUTHOR Dickinson, Valarie L.
TITLE Oil and Water Don't Mix: What about Science and Language Arts?
PUB DATE Apr 96
NOTE 13p.; Paper presented at the Annual Meeting of the National Association for Research in Science Teaching (St. Louis, MO, March 31-April 3, 1996).
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Case Studies; Educational Strategies; Elementary Education; *Elementary School Science; *Elementary School Teachers; *Integrated Activities; Interdisciplinary Approach; *Language Arts; *Preservice Teacher Education

ABSTRACT

Science is generally not seen as a subject that produces literate readers and writers, which is a major goal in the elementary grades. The purpose of the study reported in this paper was to determine the development of preservice elementary teachers' (N=46) definitions of language arts over the course of a semester. It also looked at ways preservice teachers with interest and expertise in language arts and limited science background can develop an effective approach to teaching science. Results indicate that the development of the preservice teachers' ideas about what constituted language arts can be described as a process over a continuum. They began the course talking about language arts as a way to teach reading and writing. But they later related how discussions during science lessons were incorporating language arts because students were listening to others and talking out their own ideas. It was concluded that it was possible to develop the views of preservice teachers in their definition of language arts by including science content in their curriculum. Implications for teacher education and recommendations include: (1) it was possible to develop the views of preservice teachers in their definitions of language arts by including science content in their curriculum; (2) the importance of using the reflective skills of language arts to help their own students develop their ideas became apparent; (3) the preservice teachers experienced interdisciplinary instruction, and were able to relate this through their own reflective thinking in their journal entries to their future classroom experiences; (4) preservice teachers were able to take the language arts methods with which they were comfortable and use them to successfully teach science content in their science methods course; and (5) the strategies employed here may increase comfort and confidence in teaching science. Contains 23 references. (JRH)

**********
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
**********

PERMISSION TO REPRODUCE AND
DISSEMINATE THIS MATERIAL
HAS BEEN GRANTED BY
V. L. Dickinson

TO THE EDUCATIONAL RESOURCES
INFORMATION CENTER (ERIC)

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION
CENTER (ERIC)
This document has been reproduced as
received from the person or organization
originating it.
☐ Minor changes have been made to improve
reproduction quality.
• Points of view or opinions stated in this docu-
ment do not necessarily represent official
OERI position or policy.

ED 394 836

# OIL AND WATER DON'T MIX--WHAT ABOUT SCIENCE AND LANGUAGE ARTS?

**Valarie L. Dickinson**
**Department of Science and Mathematics Education**
**237 Weniger Hall**
**Oregon State University**
**Corvallis, OR 97331-6508**
**503-737-1824**
**dickinsv@ucs.orst.edu**

BEST COPY AVAILABLE

Paper presented at the National Association for Research in Science Teaching Annual Meeting, St. Louis, Missouri, March 31--April 3,1996.

SE 058 330

**Oil and Vinegar Don't Mix--What About Science and Language Arts?**

Valarie L. Dickinson , Oregon State University

**Description of the Problem**

Elementary teachers are usually very enthusiastic about teaching language arts and reading. They are confident about their own expertise in the subjects and are experienced at providing involving activities that interest their students. However, as evidenced by the 90 minutes a day spent on reading compared to the 17 minutes per day spent on science (Enochs & Riggs, 1990), science is considered a lower priority subject in elementary school (Riggs & Enochs, 1990). Elementary teachers often feel reluctant to teach science because they believe they are inadequately prepared in how to do so, and that they themselves do not have enough content knowledge. Science is also not seen as something that produces literate readers and writers, which is a major goal in the elementary grades. Though most teachers agree that science should be taught in a "hands-on" fashion, they are unsure of their abilities to conduct such activities (Atwater, Gardner, & Kight, 1991). Even when using a curriculum designed to make teaching science teaching easier, elementary teachers feel inadequately prepared (Bybee, 1991). Though teachers may realize they need to spend more time teaching science (Enochs, 1982), when time is short, science is often shortchanged in the elementary classroom (Cox & Carpenter, 1989). Teachers who do feel adequately prepared and confident will teach more science in the elementary school (Perkes, 1975). The challenge is to help elementary teachers use the enthusiasm, expertise, and confidence they have for teaching language arts to help them improve their teaching of science.

Tompkins and Hosskison (1994) define language arts in the classroom as the development of reading, writing, speaking and listening skills in purposeful settings. They advocate having students discuss topics and listen to each other's viewpoints. Students should read and write based on their experiences. Language arts shouldn't be limited to a prescribed time of the day, but be incorporated into other curricular areas. Science can provide purposeful experiences and topics for writing and discussion in language arts. Flick (1995) described his study in which one experienced teacher strengthened her background in science, and used her expertise in language arts to provide good science instruction. In addition, the teacher's expertise in orchestrating discussions enabled her to uncover children's ideas about the science topic and to help students negotiate meaning. Roth, Peasley, Hazelwood, Hasbach, Hoekwater, Ligett, Lindquist, and Rosaen (1992) discussed that though their study of various curricular areas was not intended to be one of integration across the curriculum, the students spontaneously drew connections across their writing, social studies and science classes. This occurred even though there was no thematic overlap of the topics in the different subjects. Students in the 1992 study stated that discussion with peers and oral and written questions from the teacher were helpful to their learning of science, and that grades given were not helpful to their learning of science. This lends support to integrating science within language arts. Mishler (1982) conducted a meta-analysis of various studies relating hands-on science and its effects on language arts skills by elementary students. Overall findings indicated that activities involved in hands-on science have potential for enhancing cognitive development. This paves the way for the most meaningful language

development through reading, writing, listening and speaking. She advocates using an integration of science into language arts whenever possible because it helps develop cognitive skills beneficial to both science and language arts learning.

The problem explored in this project was to determine how preservice elementary teachers' ideas about language arts developed during the course of a semester when science lessons and teaching strategies were integrated into the language arts methods classroom. Program goals included helping preservice teachers to (1) see the value of what they knew about language arts for teaching science, (2) think of language arts as a tool for exploring other subjects, in particular science, (3) see that by integrating language arts into science more time would be allotted in the classroom to teach science, and (4) recognize that skills in language arts can increase competence in science teaching. During the course of the class, students were developing teaching skills in language arts and gaining a commitment to inquire into the science subject matter to learn more about it.

## Purpose

The purpose of this study was to determine the development of preservice elementary teachers' definitions of language arts over the course of a semester. Students' original ideas about language arts were collected, and science pedagogy and content were incorporated into the course. Concluding ideas were collected to see what developments occurred in the thinking of the preservice teachers concerning their views of language arts. In addition, the current study looks at ways preservice teachers with interest and expertise in language arts and limited science background can develop an effective approach to teaching science.

## Research Methodology, Design, and Procedures

The methods used in this study were qualitative in the Chicago School tradition (Bogdan & Biklen, 1992). The design consisted of case studies of two groups of 23 preservice elementary teachers enrolled in one semester language arts methods courses at a four-year research university. The purpose of the language arts classes was to prepare students to teach reading, writing, speaking, and listening skills in their future elementary teaching positions. The first group was enrolled in the fall semester, and the second group in the spring semester. The second group served as a replication for the study. Out of both classes there were only two students with an intent to teach middle school science. One student minored in earth science in which she took 22 credits of science, and the other majored in general science, in which he took 45 credits of science. These two students were both in the first semester course section. The other students in the course varied in their choices of four minors: reading, bilingual education, special education, or English as a second language (ESL). These students were required to enroll in 6 semester credits of lower division math, 8 semester credits of lower division physical science, and 4 semester credits of lower division biology. Few of the students had completed these requirements at the time of the study. The courses were taught by the author who was an elementary teacher and enrolled in a doctoral program in science education. About 75% of each class was concurrently enrolled in a science methods

course taught by a different instructor. Data collected were from assignments and interactions that were natural outcomes from the course. Data included daily journal entries that were completed outside of class by the students, written and oral presentations of student work, and notes made of discussions, formal and informal, among students and between instructor and students. Videotapes were made of the students engaging in science explorations during their language arts class, and of their discussions of the relationships between the two disciplines as they were investigating. Contrasts between the science and non-science majors were made to illustrate any differences in how they viewed the course.

Writing assignments were selected to gain insight into individual thinking. Thinking skills are best taught when connected to content, and writing provides a context for thinking about the content (Langer & Applebee, 1987). Writing was chosen to provide students opportunities for reflection for two reasons. First, since writing is a component of language arts, it provided a model for how students could use writing in their own classrooms. Secondly, writing has been defined as a "tool for learning " (Mayher, Lester & Pradl, 1983). It has also been shown that writing can serve as a way to improve scientific reasoning skills (Keys, 1994). Science and writing processes are similar, and both help learners construct understandings (Glynn & Muth, 1994). Personal writing, in which students choose their own words to discuss what they are learning will allow students to sort through and clarify their ideas. The emphasis in this kind of writing is on students' personal ideas, not on the "correctness" of the mechanics, enabling students to freely think through what they are learning. In many previous studies it has been shown that writing assignments in science classrooms have not emphasized expressing and exploring ideas, but these types of writing would encourage more learning (Rivard, 1994). Langer and Applebee (1987) state that when in the active role of the writer, the student must organize and reformulate ideas in the process of writing about them. To capitalize on using writing to learn, students in the current study were assigned to keep an out-of-class journal in which they reflected on what they were learning about science content, as well as how they saw strategies presented in class may fit in their own classrooms. Fulwiler (1942) recommends using journals because it "generates ideas, observations, emotions" (p. 15). Journal writing focuses attention on a topic and makes it harder for students to remain passive. Journals allow teachers to read and respond to individual ideas on a private basis. They allow teachers to note developing ideas and to ask directed questions of students to help them further their thinking. Journal topics were assigned each class period, and the instructor read and responded to each and returned them the following session. Roth et al (1992) comments that the fifth grade students in this study saw journals as important to starting scientific arguments, and clarifying ideas to share and to "match up" with others. This relates to using the written word as a way to make meaning, and to develop concepts.

**Limitations of the Study**

Because the instructor of the courses was also the researcher in this study, there was threat of researcher bias. It could be that the researcher was seeing what she hoped to find. To help address this threat, the results of this study were shared with a science

educator and language arts specialist, both holding doctorates in their respective fields. Each was given copies of the paper and reactions were collected from each during hour-long audio-taped interviews. Both specialists agreed that it was logical to draw implications and developing ideas through student writings and journal entries. The language arts specialist stated journals serve as a "dipstick" to check student understandings about strategies and content, and that they help students become more metacognitive and aware of their own thinking. It makes sense that the journals, which encourage reflective thinking, would help students see what they are learning and would influence them to teach in that fashion. Both agreed that journals are a valid method of data collection because they enable a researcher to gather data over time as opposed to a one-shot collection. Journals are more authentic because they are meaningful and researchers can learn more from them in ways that are better than surveys or questionnaires. The language arts specialist stated he saw nothing in the implications section that could not be drawn from the data. The science educator agreed, but cautioned against drawing similar conclusions for all students in the course, noting that students respond differently to teaching strategies, and this should be reflected in the results.

## Components of the Course

There were five major components of the course that were concurrently instituted. The components were chosen to help enable teachers to use strengths in language arts to improve science teaching.

### Component One: Modeling Interdisciplinary Instruction

In a study that explored the effectiveness of integrating reading, writing, and science, Gaskins, Guthrie, Satlow, Ostertag, Six, Byrne, and Connor (1994) found that using an interdisciplinary approach was difficult and stressful for teachers. Experiencing integrated science and language arts instruction could be an important strategy in helping elementary teachers become more confident in using such methods. Baker and Saul (1994) showed that even novice teachers were able to use integrated methods of teaching science and language arts. Baker (1996) described the use of language arts for teaching science in her fourth grade classroom. Thus, the first component consisted of the instructor modeling how science can be integrated into the language arts curriculum by leading the preservice teachers through science units. Topics were chosen that would be commonly found in the elementary curriculum, yet preservice teachers were encouraged to develop their own understandings of these concepts. They were not to focus only on the teaching strategy, or what they hoped children would learn from the teaching, but to also develop their own understandings of the content. They were lead through explorations in reflection, probability, states of matter, and optical illusions. Preservice teachers engaged in hands-on activities, and small group discussions of student understandings of the science content were videotaped as the investigations proceeded. Following the hands-on activities whole-class discussions were held concerning developing understandings of the science content, and where language arts (talking,

listening, reading, writing) might fit, or may naturally be, within the lesson. They were then assigned to write in their journals their own developing ideas of the science content, and were encouraged to record language arts connections as well.

**Component Two: How it Works in a Real Classroom**

The second component consisted of sharing similar investigations conducted by elementary children. Videotapes of first grade students undertaking investigations such as those the preservice teachers were conducting were shown. First grade students were shown engaging in whole class and small group science discussions, during which many unconventional ideas were uncovered that surprised the preservice students. Preservice teachers commented that without the use of discussions they would not know of the alternative conceptions their children will bring with them to the classroom. To further the discussion on ideas children hold preservice students were shown the videotape "A Private Universe: Misconceptions that Block Learning." In this videotape high school students, as well as graduates of Harvard, reveal science misconceptions that have served them well and have stuck with them through their lives. The preservice teachers were asked to respond in their journals concerning their thoughts of alternative conceptions children bring to the classroom, how discussions may help to reveal these to the teacher, and subsequent steps the teacher may take.

Videotapes of the first graders investigating problems were also shown to the preservice teachers. In a discussion of these videos, students talked about what the children were learning, and how their small group discussions helped the children decide what steps to take in their problem-solving. Children were also shown writing in their journals, and samples of this work were shared with the preservice students. Preservice teachers were asked to reflect in their own journals of any usefulness they saw of journal writings in helping children to learn science.

At the preservice teachers' request, a hand-out was provided describing a typical day in the elementary classroom of the instructor. This gave an overview of how one elementary teacher chose to integrate science and language arts, among other curricular areas.

**Component Three: A Comfortable, Risk-free Environment**

The third component was to create a comfortable environment so the preservice teachers would be willing to openly share ideas of the science content and pedagogy. They were encouraged to discuss science content and pedagogy in small groups. All ideas were accepted and encouraged. The instructor lead class discussions about connections preservice teachers were making between language arts and science, as well as their ideas of science content. Ideas were recorded on butcher paper by the instructor as well as students, and posted in the classroom to show they were valued and accepted, and to allow preservice teachers to refer to them. The instructor was willing and always available to discuss ideas on an individual and impromptu basis.

**Component Four: Class Projects**

In addition to the daily journal entries, the fourth component was to assign projects designed to allow preservice teachers to be open to incorporating other curricular areas into language arts. They were not required to integrate other subjects, but were allowed the choice to do so. Reading and writing activities can serve as conceptual tools to help students analyze, interpret, and communicate scientific ideas (Glynn & Muth, 1994). The first assignment consisted of two reports on articles of professional teaching journals. Preservice teachers were allowed to choose teaching journals from any curricular area. They were asked to write a short summary of the article, and then a description of their reactions to the article. A second assignment was for them to develop a thematic unit that included lesson plans for curricular areas other than language arts and then to teach a lesson from the unit to the class. They were not required to include science or math within the unit. For their presentation they were allowed to choose any lesson from their unit.

**Component Five: Reflection**

The final component was to encourage students to reflect on their learning and to imagine how their ideas might work in their future classrooms. This was done through daily journal assignments and classroom discussions. Reflection has been shown to be an important component in not only learning, but also teaching science concepts (Baird, Fensham, Gunstone, & White, 1991). It was hoped that by showing preservice teachers how they could learn science content through reflection in journal entries and discussions, they would take this to their own classrooms and help children reflect on their own science learning. They were asked to write an initial journal entry describing their definitions of language arts. They were also required to write an entry discussing how they believed children best learn. Subsequent journal entries throughout the semester were collected to record their developing ideas about language arts, its integration with science, and understandings of science content.

The journal also served to check ideas at the end of the semester through three final journal entries. These journal entries helped to show preservice teachers' current views of language arts. First, they were required to make a list of things that reminded them of language arts. Second, they were required to write a description of their current definitions of language arts. Third, they were asked to discuss their ideas of why science could be integrated into the language arts curriculum. All data were analyzed for developments being made in how the preservice teachers viewed language arts.

Small and large group discussions were held to help preservice teachers share ideas and to see what others in their class thought about science content and teaching strategies. They were encouraged to orally share with one another connections they were making to help them further develop their own ideas.

**Findings**

The development of the preservice teachers' ideas about what constituted language arts can be described as a process over a continuum. From their own explorations studying science through language arts, their views began to develop. They began the course talking about language arts as a way to teach reading and writing. They later related how discussions during science lessons were incorporating language arts because students were listening to others, and talking out their own ideas. The preservice teachers minoring in reading, bilingual education or ESL appeared to adapt to the strategies quite well. They seemed to embrace the idea of using language arts to help teach science. The science minors were comfortable using the strategies as well, because they were able to use their areas of expertise in their language arts methods course. About three-fourths of the language arts class was concurrently enrolled in a science methods course taught by a different instructor. In their science methods course preservice teachers were required to teach a week-long science unit. Many of them included language arts methods to teach their unit, and the strategies were accepted by the science methods instructor. Two methods that were especially well-received were the use of journals as a learning and assessment tool, and the use of K-W-L. "K-W-L" stands for "What I Know, What I Want to Know, and What I Learned." Some preservice teachers used the K-W-L method to collect their peers' ideas and their development during the week-long unit. They would make three-column charts, and at the top of each column was listed either K, W or L. As their peers were learning from their explorations, the language arts preservice teachers would list science student responses under the appropriate column. This technique was modeled in the language arts course. They also chose to have their science course peers record observations, results, and discuss their changing ideas, in journals they made for the week. This mimics what they were required to do in the language arts course. Both strategies were adopted by students in the science methods class who were not in the language arts course.

The preservice teachers were also required to read two articles in professional teaching journals. They were asked to report on the journals in a way they might discuss articles with colleagues. They were allowed free choice of teaching journal. For the first paper all preservice teachers chose to report from a language arts journal, such as *The Reading Teacher* or *Language Arts*. For the second paper they expanded their journal selection to include those from other curricular areas, such as *Science and Children, Arithmetic Teacher*, and *Technology Review*. Though not requested to do so, they would invariably include in their reflection paragraph reasons that their "unorthodox" choice of journal really did relate to language arts. This practice in "convincing" someone that science, math, or technology had some relationship to language arts should be helpful for their inservice years during which they will wish to continue to incorporate other subjects into their language arts program. They will be able to justify their teaching methodology.

One-half of the preservice teachers in each class chose science-related concepts such as "weather," "space travel," or "water," on which to develop their thematic unit. The others chose either child-centered topics such as "myself," or social studies concepts such as "Japan" or "Native Americans." Within each unit the preservice teachers included

science connections. Over half chose to present a science lesson to their peers during their unit lesson presentations.

Definitions of what constituted language arts developed as evidenced by responses to the final three journal entries. The preservice teachers' lists of things that reminded them of language arts included "M & M's" (from a mathematics and technology unit), "journals," "K-W-L," "Oobleck" (science unit), "talking, listening, reading and writing," " reflection and optical illusions" (science unit), "fits other things in (to the curriculum)," and "science." From their journal entry describing their new definition they discussed language arts as "incorporating all curricular areas," "a tool for learning other things," and it could be made "more interesting if kids have a purpose for writing about things." To why science was integrated into language arts, the responses varied from "to show us how easy it is to integrate language arts," "to show us how a teacher needs to teach in order to fit everything into the day," "to show us how to 'make time for science,'" to "because you love science."

## One Teacher's Use of the Methods

The researcher kept in touch with one student from the study to track any effect this instruction may have had on the preservice teacher's methods used with children. This preservice teacher, Judy (pseudonym), was placed in a third grade elementary classroom for her internship. Judy was not the top student in the language arts methods course, nor was she one of the science minors. Her major was elementary education with a minor in special education. The researcher kept in touch with Judy through electronic mail, letters, and phone calls during the course of her internship. She was selected to track because she was willing to keep in touch, and because she had developed a rapport with the researcher.

During her teaching of third grade Judy was called on to teach a science unit on 'bones.' She elected to use her language arts period to create more time to teach science during her internship. Judy employed the same strategies of K-W-L and journal writing with her third graders she had experienced in the language arts methods course. She believed her students were served well by the integration of science into language arts. She believed the variety of instructional methods enabled her to reach more students. She also indicated her supervising teacher was pleased with the success of the unit.

## Implications and Recommendations

The results of the study show several implications for teacher education programs. First, it was possible to develop the views of preservice teachers in their definition of language arts by including science content in their curriculum. Many saw language arts as a tool to explore other subjects, rather than only an end to itself. They saw the language arts period as a time during which other subjects can be incorporated, and were able to defend their choice to integrate other subjects. They saw the connections between using writing, reading, listening, and speaking during other curricular areas as being a purposeful use of language arts. Secondly, the importance of using the reflective skills of language arts to help their own students develop their ideas

became apparent because this is how they proceeded through their methods class. They saw discussions as important in helping to see the unconventional ideas students bring with them to class. This influences their teaching of science because they know the ideas their students already hold. Several preservice teachers said they believed that journals would be indispensable in their own classrooms because they are so helpful to the children's' developing ideas of the content, and helpful to the teacher in assessing the development of student learning and in knowing which direction to proceed with future lessons. Third, in this time of educational reform during which teachers are being asked to integrate subjects and give purpose to their lessons, the preservice teachers experienced such interdisciplinary instruction, and were able to relate this through their own reflective thinking in their journal entries, to their future classroom experiences. Fourth, many were comfortable using these methods, which likely enhanced their science teaching. They were able to take the language arts methods with which they were comfortable, and use them to successfully teach science content in their science methods course. In addition, other science course students not enrolled in language arts methods chose to use the strategies by their peers who were enrolled in language arts. This suggests that the methods are not only comfortable for the students to use, but are also fairly simple to implement, and may increase time spent teaching science. Fifth, these strategies may increase comfort and confidence in teaching science. Judy, the preservice teacher who was followed in her internship, indicated that she had always found science intriguing, but had not felt qualified to teach it. She had been unsure of a way to reach all students, and of how to be more sure of her own abilities in teaching science. Judy indicated that by teaching science through language arts she was able to provide more opportunities for learning science, and thought children improved their learning of science as well as language arts. She stated that science became more appealing for her by teaching it through language arts. This leads to the implication that an elementary teacher whose first love and area of expertise is language arts can use that to enhance the teaching of science.

Several future studies are suggested by outcomes of this exploration. First, students in these courses were able to learn science content through the language arts methods, and then chose to take these methods to their own content teaching in their science methods course. This could lead to finding a way for teachers to learn more science through learning a variety of teaching methods. Teaching science through the comfortable and familiar setting of language arts could encourage teachers to learn more science. Secondly, students in these classes became aware of the importance of knowing the ideas children bring with them through their own developing expertise in conducting discussions. They realized that without holding discussions about science concepts they would not know the ideas their students will bring with them, and wouldn't really understand what the children were actually learning. This instruction in discussion techniques in language arts combined with science instruction could lead to teachers becoming aware of, and seeking to address, their own students' ideas and science misconceptions. Thirdly, preservice teachers in this type of course would need to be followed to see how they implement the strategies learned in their own classrooms, and whether these teachers would be more comfortable with science and would choose to spend more time teaching science.

**References**

Atwater, M. M., Gardner, C. & Kight, C.R. (1991). Beliefs and attitudes of urban primary teachers toward physical science and teaching physical science. *Journal of Elementary Science Teaching, 3* (1) 3-11.

Baird, J. R., Fensham, P. F., Gunstone, R. F., & White, R. T. (1991). The importance of reflection in improving science teaching and learning. *Journal of Research in Science Teaching, 20* ,163-182.

Baker, D. M. (1996). It's write for science. *Science and Children, 33* (5), 24-28.

Baker, L., & Saul, W. (1994). Considering science and language arts connections: A study of teacher cognition. *Journal of Research in Science Teaching, 31*, 1023-1037.

Bogdan, R. C., & Biklen, S.K.(1982). *Qualitative Research for Education.* Needham Heights, MA: Allyn & Bacon.

Bybee, R. W. (1991). *The Reform of Elementary School Science.* Address presented at the Conference of Critical Issues in Reforming Elementary Teacher Preparation in Mathematics and Science. Greeley, CO October 10-13.

Cox, C.A. & Carpenter, J.R. (1989). Improving attitudes toward teaching science and reducing science anxiety through increasing confidence in science ability in inservice elementary school teachers. *Journal of Elementary Science Education, 1* (2), 14-34.

Enochs, L.G. (1982). Why not teach science? *Science and Children, 20* (1), 22-24.

Enochs, L.G. & Riggs, I.M. (1990). Further development of an elementary science teaching efficacy belief scale instrument: A preservice elementary scale. *School Science and Mathematics, 90*, 694-706.

Flick, L.B. (1995). Navigating in a sea of ideas: Teachers and students negotiate a course toward mutual relevance. *Journal of Research in Science Teaching, 32*, 1065-1082.

Fulwiler, T. (1942). *Teaching With Writing.* Portsmouth, NH: Boynton-Cook.

Gaskins, I. W., Guthrie, J. T., Satlow, E., Ostertag, J., Six, L., Byrne, J., & Connor, B. (1994). Integrating instruction of science, reading, and writing: Goals, teacher development and assessment. *Journal of Research in Science Teaching, 31*, 1039-1056.

Glynn, S. M., & Muth, K. D. (1994). Reading and writing to learn science: Achieving scientific literacy. *Journal of Research in Science Teaching, 31*, 1057-1073.

Keys, C. W. (1994). The development of scientific reasoning skills in conjunction with collaborative writing assignments: An interpretive study of six ninth-grade students. *Journal of Research in Science Teaching, 31,* 1003-1022.

Langer, J. A., & Applebee, A. N. (1987). *How writing shapes thinking.* Urbana, IL: National Council of Teachers of English.

Mayher, J.S., Lester, N. & Pradl, G.M. (1983). *Learning to Write, Writing to Learn.* Portsmouth, NH: Boynton-Cook.

Mishler, C.G. (1982). *The Integration of Experimental Science with Language Arts Instruction in the Elementary Curriculum.* Unpublished manuscript. Indiana University at South Bend.

Perkes, V.A. (1975). Relationships between a teacher's background and sensed adequacy to teach elementary science. *Journal of Research in Science Teaching, 12,* 85-88.

Riggs, I.M. & Enochs, L.G. (1990). Toward the development of an elementary teacher's science teaching efficacy belief instrument. *Science Education, 74,* 625-637.

Rivard, L. P. (1994). A review of writing to learn in science: Implications for practice and research. *Journal of Research in Science Teaching, 31,* 969-983.

Roth, K.J., Peasley, K., Hazelwood, C., Hasbach, C., Hoekwater, E., Ligett, C., Lindquist, B., & Rosaen, C.L. (1992). *Integration from the Student Perspective: Constructing Meaning in Science.* Elementary Subjects Center Series No. 63. East Lansing, MI: Center for the Learning and Teaching of Elementary Subjects.

Schnepps, M.A. (1988). *A Private Universe: Misconceptions that Block Learning.* San Francisco, CA: Astronomical Society of the Pacific.

Tompkins, G.E. & Hoskisson, K. (1995). *Language Arts Content and Teaching Strategies.* Englewood Cliffs, New Jersey: Merrill.